Uncorrected position errors in current geodetic VLBI analysis

A. Niell
2004 February 1

Introduction

In this note I want to make a case to the geodetic VLBI community that known errors should be corrected. I will give evidence for known height errors, then raise the issues of how we get the necessary input information collected or measured, then how does this information get into the analysis. In order to make decisions on the inclusion of the effects in the analysis, it will be necessary to establish some standards for reference epoch and reference values, e.g. for antenna height or for atmosphere pressure at a reference time epoch.

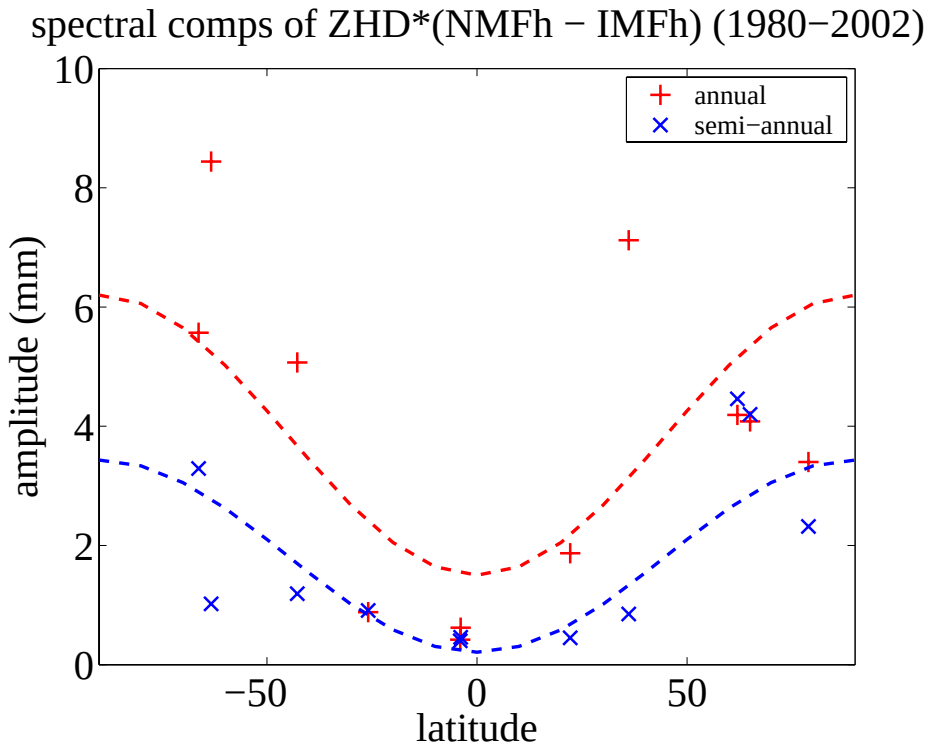
Sources of error

There are at least three sources of position error that are not corrected in VLBI (and GPS) data analysis:

1) atmosphere model (better models available)
2) thermal deformation (models and measurements available)
3) local hydrologic effects, e.g. groundwater withdrawal (some measurements)
4) other effects?

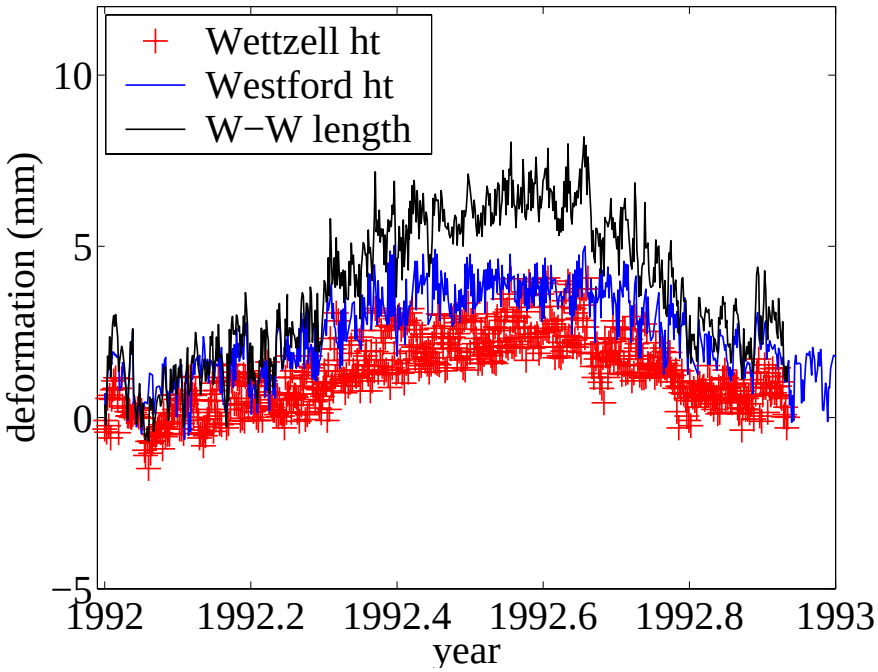
1) Atmosphere:

NMFh causes annual and semi-annual errors in height with amplitudes up to 8 mm for annual and to 4 mm for semi-annual (obtained by comparison of NMFh to IMFh for 1980 – 2002)



2) Thermal deformation:

Onsala and Wettzell have been measuring changes in the height of the intersection of axes for some time now. At Westford the changes were measured over one year in 1984-85 well enough to derive a seasonal model based on outside temperature. Combining this with the measurements at Wettzell I came up with the following figure that shows the effect of the deformation at the two antennas on the baseline length.



3) Local hydrologic changes:

Munekane et al (GSI) reported at the 2003 Dec AGU that the height changes of the TSKB GPS site are correlated with vertical displacements measured by a subsidence meter in a nearby well. (I think the pk-to-pk change was about 5 mm, but I don't have a figure for confirmation.) Through modeling they conclude that changes in the water table between 40 m and 190 m are responsible. These changes are attributed to withdrawal and replenishment of water related to the growing of rice nearby. The VLBI antenna, with a base that is above the 40 m level, moves coherently with TSKB, and this is consistent with the model.

There should be a difference between the GPS and VLBI vertical changes since the thermal deformation of the Tsukuba 32m could be similar to Westford and Wettzell for similar size antenna and annual temperature variation. This difference might be used to further refine the hydrological model.

Measurement and data collection

For antenna deformation direct height measurement provides the most accurate correction. However, this only applies to the time for which the measurements have been made. Outside of that time a model must be used, most likely based on temperature. Therefore temperature measurements must be available from a location that can be related to the antenna deformation. Also, an epoch and temperature must be associated with a height in order to provide an "absolute" height reference.

Similarly, atmosphere pressure must be referenced to a standard value and an epoch

chosen for which that pressure applied.

For hydrological effects, should these be applied as corrections, or is the effect something that is to be measured after other effects have been removed?

These supplementary data must be calibrated, monitored, stored somewhere, and made available to the analysis.

Implementation of corrections in analysis

There are several places in the data analysis for the inclusion of measured and modeled corrections:

1) correlator
2) calc
3) solve daily solution
4) global (all data) analysis (quarterly update?)
5) post-solve analysis

Different corrections may be treated differently. Thermal deformation (and manu other effects) requires the option of using the direct measurements or the modeled correction. Continuity must be ensured where transitions occur.

Accuracy goals

If we are to reach height uncertainties of order 1 mm in the future (SESWG report), then errors in corrections must be smaller than this. One possible redeeming feature is that the integration time is somewhat uncertain, e.g. 24 hours, 1 week, 1 month average.

For horizontal measurements the uncertainties are generally about one-third of the vertical. However, this doesn't necessarily apply for the polar regions. Therefore thought must be given to horizontal as well as vertical corrections and the desired accuracy.

Why make corrections?

It is not likely that these corrections will reduce our baseline length time evolution plots to straight lines within the formal uncertainties. However, the uncertainties in what modeling error has not been accounted for (i.e. RMS^2 – (known errors)^2) will be reduced as each effect is removed, making the evaluation and identification of candidates for the remaining errors easier.

Goals of this workshop

Initiate discussion on:

1) how to include atmosphere model based on NWM (IMF or VMF)
2) how to get deformations measured for more antennas
3) how to include deformation measurements and models in analysis
4) standards for reference values
5) propose other sources of uncorrected errors and how to measure or model
6) ???